

found at: page 5, lines 21-22; page 18, line 5-6; and page 24 lines 9-11, for example. Claims 10 and 11 have been amended to depend on claim 1 instead of claim 8 and claim 10, respectively. New claim 20 has been added to specify that said means for heating the downstream side of the catalyst bed further comprising an electric heater. Support for adding claim 20 can be found throughout the specification, including at page 16, lines 16-20, for example.

Claims 21-26 have been added to specifically claim the embodiment of FIG. 3. Support for adding claims 21, 23, 24, 25 and 26 may be found, in addition to the embodiment of FIG. 3, at original claims 1, 3, 4, 6 and 8, respectively. Support for adding claim 22 can be found throughout the specification, including at page 16, lines 16-20, for example.

The proposed drawing amendment is enclosed to more clearly illustrate the direction of reformed gas flow through the hydrogen purifying apparatus as disclosed in the specification and claims of the invention. Approval is respectfully requested. Amended formal drawings will be submitted upon receipt of a Notice of Allowance.

Rejection Under 35 U.S.C. §103

The Examiner has rejected claims 1, 6, 8-17 and 19 under 35 U.S.C. §103(a) as being unpatentable (obvious) over U.S. Patent No. 5,879,051 of Heil, *et al.* ("Heil").

The Examiner asserts that Heil discloses (Fig. 1) a hydrogen purifying apparatus for oxidizing and removing carbon monoxide in a reformed gas containing carbon monoxide in addition to the main component of hydrogen gas, the apparatus comprising: a reaction segment 5 having a catalyst layer for oxidizing carbon monoxide; a reformed gas supply inlet 2 for supplying the reformed gas to the reaction segment via a reformed gas supply pathway; an oxidant gas supplying segment 3 for supplying an oxidant gas to the reformed gas supply pathway; and a water-cooled apparatus 6 for cooling the upstream side of the catalyst side.

Applicants assert that Heil discloses an apparatus for selective catalytic oxidation of carbon monoxide in a mixed gas stream containing hydrogen (Heil, claim 1). The apparatus is a CO-oxidation reactor 1 which consists of three oxidation stages marked I, II, and III (Fig. 1, and col. 3, lines 17-18). The mixed gas stream containing hydrogen is supplied to the CO-oxidation reactor 1 in the vicinity of the first oxidation stage I (col. 3, lines 21-23). In the individual oxidation stages I-III, carbon monoxide is reduced in stages by selective oxidation on suitable catalysts (col. 3, lines 29-31). The oxidizing gas is added to the mixed gas stream through several inlet openings 3 along the CO-oxidation reactor. Heil also discloses that it is advantageous to apply the catalyst to metal catalyst support units 5. Further, Heil discloses cooling chambers 6, which are traversed by coolant provided to cool the CO-oxidation reactor, such that oxidation stages I and II have separate cooling chambers 6 to which the coolant is metered through a valve 7 (col. 3, lines 50-54).

The present invention is directed to a hydrogen purifying apparatus for oxidizing and removing carbon monoxide comprising a reaction segment having a catalyst bed for oxidizing carbon monoxide, a reformed gas inlet, an oxidant gas supplying segment, a cooler for cooling an upstream side of the catalyst bed, and means for heating a downstream side of the catalyst bed, wherein the means for heating is a portion of the reformed gas pathway formed in proximity with the catalyst bed (claim 1).

Applicants respectfully, but strenuously, argue that the structural elements in claim 1 of the present application are different and nonobvious when compared to the structural elements in Heil. In response to Applicants' prior amendment, the Examiner concludes that "... Heil discloses a heat exchanger that regulates the temperature of the catalyst by means of a heat exchanger fluid. This is a structural feature. Whether the heat exchanger fluid supplies heat or

withdraws heat is a feature of the method of operation and is not a structural feature of the apparatus." The Applicants disagree with this conclusion.

Heil actively regulates the temperature of the catalyst by the quantity of oxidizing gas that is added to the reaction chamber 2 (col. 6, lines 50-54) in conjunction with passive cooling that occurs as a result of the mixed gas stream in contact with the outer walls of the reaction chamber 2 (col. 4, lines 7-11).

By contrast, claim 1 of the present application provides a distinct structural advantage by using a cooler 17 to actively cool the reformed gas prior to entering the catalyst layer 11. Unlike Heil, the present invention does not depend on the quantity of oxidizing gas to control temperature. Therefore, Applicants argue that a significant structural difference exists between Heil and the present invention that is not merely a method of operation.

Another structural difference between the two inventions is the inclusion of a reaction segment 18 in the present invention that separates the reformed gas from the catalyst layer 11 as it proceeds along the reformed gas pathway. As shown in amended Fig. 3, the catalyst layer 11 of the present invention is adjacent to and enveloped in close proximity to the reformed gas pathway. This enables the downstream side of the catalyst layer 11 to be heated by the reformed gas. After this, the reformed gas is cooled by passing through a cooler 17 and on to the catalyst layer 11. As such, a means for heating the downstream side of the catalyst layer 11 is provided by the reformed gas which, as the Examiner acknowledges, is not disclosed in Heil. Using the reformed gas to heat the catalyst bed does not amount to an obvious substitution of one heat exchange fluid for another but, rather, is the result of structural differences in the apparatus.

Further, it is the structural elements of the present invention, primarily the cooler 17 and the reaction chamber 18, that enable the hydrogen purifying apparatus to establish a wide

temperature profile along the catalyst layer 11. It is known in the art that a change in type and/or amount of oxidant gas supplied to the reaction segment during selective CO oxidation can cause a fluctuation of the O₂/CO ratio and a resulting decrease in heating efficiency of the apparatus. The present invention overcomes this undesirable process condition by maintaining the desired temperature profile along the catalyst layer 11 using the claimed structure, despite changes in oxidant gas and resultant changes in the O₂/CO ratio. The resulting improved temperature profile is highly stable and easily controlled. Heil does not teach or suggest this nonobvious feature of the present invention.

Applicants respectfully disagree that it would have been obvious to one skilled in the art to use the reformed gas as a means for temperature control. While one skilled in the art may be motivated to control exothermal CO oxidation along the reactor path, the means for obtaining such control, as set forth in claim 1 of the present invention, is not obvious. As described, the apparatus in Heil is quite different from the design and structure specified in claim 1. Heil utilizes individual oxidation stages as a means for controlling exothermic oxidation along the reactor path. Meanwhile, the structural features or elements of the present invention are such that: (1) the reformed gas is cooled before being supplied to the catalyst bed; and (2) the downstream side of the catalyst bed is heated by the reformed gas thereby improving the temperature profile along the catalyst layer 11 and, thus, creating a highly stable reactor. As a result, the differences between Heil and the present invention are such that the subject matter of claim 1 would not have been obvious at the time of the invention to a person having ordinary skill in the art.

With regard to claim 6, the Examiner's response to Applicants' prior amendment was that "Heil's valve has the same capability. How that capability is used, for example

controlling in response to temperature, is a method of operation and does not patentably distinguish over the prior art.” Applicants argue that the valve in Heil and the flow rate control valve 4 of the present invention are significantly different such that the present invention is patentably distinguished from the prior art. The valve in Heil is actually a metering device 4 provided at each of the inlet openings 3 to regulate or control the addition of oxidizing gas. Further, Heil is interpreted to teach that the metering devices 4 are the primary means by which the apparatus in Heil controls temperature in the reactor “. . . to achieve practically any desired temperature profile along the flow path of the reaction gas mixture.” (col. 6, lines 55-57).

Conversely, the present invention recognizes that in order to effectively oxidize carbon monoxide in the reformed gas, open air must be combined with the reformed gas in a specific volume ratio. To accomplish this, the air volume supplied to the apparatus is regulated by the air flow rate control valve 4 such that oxygen is maintained at one to threefold volume ratio with carbon monoxide (page 15, lines 1-4). The reformed gas mixed with air is then cooled by a heat exchanger (Fig. 1) 7 to the activating temperature of the catalyst (Fig. 2) before being introduced to the catalyst layer 1. Unlike Heil, the air flow rate control valve 4 establishes the oxygen to carbon monoxide volume ratio as the reformed gas enters the catalyst layer 1. Unlike Heil, the air flow rate control valve 4 is not the primary means for obtaining a desired temperature profile along the reformed gas pathway. Therefore, Heil’s metering devices 4 do not have the same capability as the air flow rate control valve 4 of the present invention. Thus, Applicants respectfully traverse the §103(a) rejection of claim 6 on the basis that the current invention can be patentably distinguished from the cited prior art for the reasons set forth above.

With respect to claim 8, the Examiner asserts that Heil discloses passing the reformed gas through the catalyst layer in a second direction (Fig. 1). The Examiner also asserts

that Heil discloses passing the heat exchanger fluids through the apparatus (Fig. 1(6)) and that the direction of flow is an intended use and does not patentably distinguish the invention from the prior art.

Heil discloses passing the reformed gas through a series that includes a reaction chamber 2, static mixing structures 8, and catalyst support units 5 all in the same direction as a coolant which passes through a cooling chamber 6 (Fig. 1). The structural features of the apparatus of Heil do not enable the mixed gas and the coolant to flow in opposite directions nor is it possible for the reformed gas to flow in a first direction prior to passing through the catalyst support units in a second direction.

As previously asserted, in the present invention the direction of flow is established by the structural features of the invention (see, *e.g.*, amended Fig. 3). Those features enable the reformed gas to flow in a first direction prior to passing through the catalyst layer in a second direction wherein the first direction and the second direction are opposing (claim 8). This opposing or counter flow, which results from the structure of the invention, is effectively used for heat exchange. Thus, the present invention can be patentably distinguished from the prior art based on structure, not just the intended use of the invention.

With respect to claim 9, the Examiner asserts that Figure 1 of Heil discloses the reaction segment placed outside the flow pathway before passing through the catalyst layer. The Examiner also states that it is not clear how Heil's reaction chamber differs from Applicant's reaction segment.

Claim 9 recites that the reaction segment is placed outside the reformed gas pathway before passing through the catalyst bed. This structural embodiment is clearly shown, for example, in Figure 4 of the application. This embodiment enables the reformed gas to heat

the downstream side of the catalyst layer 21 while the reformed gas is simultaneously being cooled (page 19, lines 23-25). Further, the structure of this embodiment, whereby heat is radiated from the periphery of the reaction segment, minimizes elevation of the temperature in the catalyst layer 21 enabling the apparatus to more easily adjust to increases in load caused by increased flow of the reformed gas (page 19, line 29 to page 20, line 3).

Heil does not disclose a reaction segment placed outside the flow pathway before passing through the catalyst layer. Instead, Heil discloses a reaction chamber 2 with static mixing chambers 8 and catalyst support units such that the mixed gas stream contacts the outside walls of the reaction chamber 2 (col. 4, lines 9-10). Unlike the present invention, the reformed gas does not initially heat the downstream side of the catalyst layer before passing a heat exchanger and then a reaction segment. Therefore, Applicants respectfully traverse the §103(a) rejection of claim 9 on the basis that the current invention can be patentably distinguished from the prior art for the reasons set-forth above.

With respect to claim 10, the Examiner asserts that Heil discloses a reaction segment that is tube-shaped where the flow pathway of the gas, before passage in contact with the catalyst, is formed around the reaction segment (Fig. 1). The Applicants strenuously, but respectfully, disagree and rely on their assertions in support of claims 1 and 8 to traverse the Examiner's rejection of claim 10.

With respect to claim 11, the Examiner asserts that it would have been obvious to place multiple parts of the modified apparatus of Heil in parallel and that the motivation would have been to permit one part to fail without affecting the performance of other parallel parts of the apparatus. Applicants strenuously, but respectfully, traverse the §103(a) rejection of claim 11 since the structure and design of the apparatus in Heil do not teach or suggest placing two or

more reaction segments in parallel. Instead, Heil is interpreted to teach that cooling chamber(s) 6 are placed in parallel with the reaction chamber 2 in order to conduct passive cooling along the mixed gas flow path (abstract). As such, the design of the apparatus in Heil teaches away from placing two or more reaction segments in parallel. Therefore, in view of Heil, there would be no motivation for placing two or more reaction segments in parallel. Thus, one of ordinary skill in the art would not have been motivated to modify Heil to arrive at the instant claims.

With regard to claim 12, the Examiner argues that Heil discloses a hydrogen purifying apparatus wherein there are a plurality of branches that supply gas from a reformed gas supply pathway and an oxidant gas supply. The Examiner acknowledges that Heil "fails expressly to disclose a branched pathway formed by a bifurcation downstream from a connection between the reformed gas supply and the oxidant gas supply," but nevertheless concludes that it would have been obvious to one skilled in the art to split the flow path downstream from a connection between the reformed gas supply and the oxidant gas supply "in order to supply a group of existing of the catalyst portions."

Applicants traverse the Examiner's rejection of claim 12 and argue that while one skilled in the art may be motivated to control the exothermal CO oxidation along the reactor path, the manner of such control as recited in claim 12 is nonobvious structural feature of the present invention. The same arguments apply with regard to claims 13-17 and 19 where various structural features, including different types of catalysts and catalyst layers, as well as apparatus for controlling the desired temperature profile along the catalyst layer are recited which are not recited in Heil and which are otherwise nonobvious in view of the prior art. Accordingly, reconsideration and withdrawal of all of these rejections are respectfully requested.

Rejection Under 35 U.S.C. §103 Over Heil In View of Trocciola

The Examiner has rejected claims 3 and 4 under 35 U.S.C. §103(a) as being unpatentable over Heil, in view of U.S. Patent No. 5,330,727 of Trocciola *et al.* ("Trocciola"). The Examiner acknowledges that Heil fails to include catalyst layers formed of different catalyst materials. However, the Examiner asserts that Trocciola discloses two different catalyst beds under different catalyst conditions that lead to different performance results (col. 6, lines 1-36) and that it would have been obvious at the time of the invention that different results from two different catalyst beds might best be accomplished by using two different types of catalyst materials. The Examiner concludes that the motivation for using two different types of catalyst materials would have been to take advantage of the differences in the catalyst materials.

Further, in response to Applicants' argument in their previous amendment, the Examiner acknowledges that Trocciola does not describe the catalyst upstream layer as being formed from different material from the catalyst in the downstream layer. Nevertheless, the Examiner argues that a variety of suitable catalyst materials are available (Trocciola, col. 5, lines 4-10) and that since different conditions are required in the two catalyst beds it would have been obvious to facilitate operation of the apparatus under two different sets of conditions by using two different catalyst beds. As a result, the Examiner contends that it would have been obvious to one of ordinary skill in the art to combine the operation of the two different catalyst beds in Trocciola with Heil. Applicants respectfully, but strenuously traverse the §103(a) rejection of claims 3 and 4 for the reasons set forth below.

While the Applicants agree that catalysts are available removing carbon monoxide from a gaseous medium, Applicants most respectfully, but strenuously, disagree that "a variety of suitable materials [are] available." As disclosed in Trocciola, certain catalysts are capable of

selectively promoting the oxidation reaction of carbon monoxide to carbon dioxide so long as the temperature at which the reaction takes place is above a threshold temperature (col. 1, lines 28-36). Thus, as Trocciola also discloses, "... it is impossible or at least not feasible to treat the incoming gaseous medium at temperatures below the threshold temperature." (col. 1, lines 58-60).

Heil is interpreted to utilize individual oxidation stages I-III in order to reduce carbon monoxide in the incoming gaseous medium at temperatures below the threshold temperature (Heil, col. 3, lines 29-34). Further, metering devices 4 are considered necessary to regulate the addition of oxidizing gas and thereby control the temperature in the CO-oxidation reactor 1. As such, Applicants assert that it is not obvious that two different types of catalyst materials could be used while still maintaining the CO-oxidation reaction. Therefore, Heil teaches away from establishing a wide temperature profile along the catalyst layer such that the upstream side of the catalyst layer is formed by a different catalyst from the downstream side whereby the catalyst on the downstream side is capable of activity at a lower temperature than the catalyst constituting the upstream side of the catalyst layer (claim 3).

Additionally, Applicants once again argue that Trocciola does not describe the catalyst in the upstream layer being formed of different materials from the catalyst in the downstream layer, where the downstream side catalyst exerts activity at a lower temperature than the catalyst in the upstream side, as in claim 3 of the presently claimed invention. Applicants assert most strongly Heil and Trocciola do not teach or suggest the use of different catalysts in the manner in which they are claimed. Further, there is no motivation to modify or combine the prior art as the Examiner has in order to identify suitable catalyst materials placed in the

structural arrangement claimed such that the hydrogen purifying apparatus functions in an efficient manner.

In support of the assertion that there is no motivation to combine Heil and Trocciola, Applicants assert that Trocciola is directed to a selective oxidation reaction, which is exothermic by nature, and takes place in two catalyst beds 22 and 32 under well defined temperature conditions. Heil is directed to a selective oxidation reaction controlled by the reaction path of a mixed gas stream. Thus, these inventions utilize two different methods to perform the respective selective carbon monoxide oxidation. Therefore, Heil would not suggest using multiple catalyst beds in its selective oxidation reaction as suggested by the Examiner.

At the time the invention was made, one of ordinary skill in the art presented with the disclosures of Trocciola and Heil would have had no reasonable expectation that the combination of Trocciola and Heil would give rise to the successful characteristics of the instant claims, namely efficient oxidation and stable removal of undesirable CO in the reformed gas (page 11, lines 13-15). Neither the disclosure of Trocciola nor the disclosure of Heil recognizes the importance of using means for cooling the catalyst layer at the upstream side, and means for heating the catalyst layer at the downstream side. Thus, neither Trocciola nor Heil, taken alone or in combination recognizes that such means facilitates efficient oxidation and stable removal of undesirable CO in the reformed gas. Reconsideration and withdrawal of the rejection are respectfully requested.

It is Applicants' continued position that even if *prima facie* obviousness could be shown based on the above-noted references and despite the Examiner's comments concerning the referenced prior art, *prima facie* obviousness is sufficiently overcome by Applicants'

hydrogen apparatus that provides efficient oxidation and stable removal of undesirable CO in the reformed gas (page 11, lines 13-15).

Finally, Applicants assert that new claims 21-26 are allowable for at least the same reasons stated above and based on additional features not shown in Heil.

CONCLUSION

Based on the foregoing amendments and remarks, Applicants respectively submit that the claimed invention for a hydrogen purifying apparatus is patentably distinguishable over the cited prior art. Reconsideration and withdrawal of the Examiner's rejections of the claims and a Notice of Allowance are respectfully submitted.

Respectfully submitted,

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Marked-Up Version of Claims 1, 8 and 10-11 in Application No. 09/357,507

- 1. (Three Times Amended) A hydrogen purifying apparatus for oxidizing and removing carbon monoxide in a reformed gas containing carbon monoxide in addition to a main component of hydrogen gas, comprising a reaction segment having a catalyst bed for oxidizing carbon monoxide, a reformed gas inlet for supplying said reformed gas to said reaction segment via a reformed gas pathway, an oxidant gas supplying segment for supplying an oxidant gas to said reformed gas pathway, a [water-cooled apparatus] cooler for cooling an upstream side of said catalyst bed, and means for heating a downstream side of said catalyst bed,

wherein said means for heating the downstream side of said catalyst bed is [selected from the group consisting of an electric heater and] a portion of the reformed gas pathway formed in proximity with said catalyst bed via a partition so as to heat said downstream side of said catalyst bed by said reformed gas before passing through said [water-cooled apparatus] cooler.

8. (Three Times Amended) The hydrogen purifying apparatus in accordance with claim 1, wherein said reformed gas flows in a first direction prior to passing through said [water-cooled apparatus] cooler, and passes through said catalyst layer in a second direction, wherein the first direction and second direction are opposing.

10. (Amended) The hydrogen purifying apparatus in accordance with claim [8] 1, wherein said reaction segment is tube-shaped and said flow pathway of said reformed gas before the passage through said [cooling means] cooler is formed around said reaction segment.

11. (Amended) The hydrogen purifying apparatus in accordance with claim [10] 1, wherein two or more reaction segments are connected in parallel. - -